Appendix F

Historical Shoreline Data and Trends

9700 Research Drive
Irvine, California 92618
949.347.2780

Coastal Resources, Processes, and Vulnerabilities

October 6, 2023

Introduction

This appendix includes a description of historical shoreline trends, an overview of coastal processes that affect the coastline, and a summary of existing vulnerabilities and coastal conditions in South Orange County.

Shoreline Trends from Monitoring Efforts

Historically (prior to the 1940s), the South Orange County coastline contained narrow beaches to the south of Dana Point. Shoreline changes have been monitored sporadically at several transects along the coastline, as shown in Figure 1. The U.S. Army Corps of Engineers (USACE) established beach transects between 1934 and 1984 to quantify shoreline/coastal processes. Other transects were added at Doheny State Beach in 2004 (Coastal Environments 2014) and by the San Clemente Shoreline Monitoring Program in 2001 (Coastal Frontiers 2023). The San Clemente Shoreline Monitoring Program ended in approximately 2012 but was restarted in 2022 with data being collected each fall and spring from San Juan Creek to San Mateo Point.

As noted in the South Orange County Regional Coastal Resilience Strategic Plan, beach erosion became problematic in the 1960s because of the lack of natural sand supply from San Juan Creek that resulted in a narrowing of usable beach width from Doheny State Beach to Capistrano Bay District. At that time, it was estimated that San Juan Creek only supplied half of the sand necessary to maintain a stable beach. In the 1960s and 1970s, significant beach nourishment occurred at Doheny State Beach and Capistrano Beach Park, as well as to the south of the study area at San Onofre State Beach (CCSMW 2005). A beach nourishment project of 800,000 cubic yards (cy) was planned to restore the beach to usable and safe dimensions (USACE 1986). Historical records show that in 1967, a large quantity of sand from old terrace deposits in Camp Pendleton was placed on the beach in response to narrowing shoreline conditions (CCSMW 2005; Coastal Environments 2014). To maximize retention of the placed sand, a groin was constructed along the west side of San Juan Creek, creating a wide, stable beach to the west of the groin (USACE 1986). In the following decade, the shoreline fluctuations increased and vacillated in the alongshore direction between erosional and accretional. Overall, the shoreline changes from 1980 to 1989 indicated an eroding shoreline downcoast of Dana Point Harbor, particularly south of Doheny State Beach (USACE 1991). Since the mid-1980s to 1990s, there has been a gradual erosion of the shoreline, resulting in narrower beaches and an increase In storm damages to railroad and public facilities along the South Orange County coastline.

In September 2022, the City of San Clemente formally reestablished a local Shoreline Monitoring Program, which had been inactive for approximately 15 years. Prior to 2022, the last complete shoreline survey of the South Orange County shoreline was conducted in 2007.

The primary goal in re-establishing a Shoreline Monitoring Program is to build a database of information on shoreline changes in San Clemente and vicinity, thereby providing a basis for evaluating effects of sea level and El Niño conditions as well as beach sand replenishment projects. The data will be used to develop a comprehensive understanding of seasonal, annual, and long-term coastal changes in the region.

The data derived by the Shoreline Monitoring Program will also be made publicly available and used to inform the City of San Clemente's Nature-Based Coastal Resiliency Project Feasibility Study. The program results will provide data needed to make informed decisions related to enhancing local coastal resiliency. The data acquired along each transect will form a continuous profile from the back beach to the offshore terminus of the transect. The offshore terminus will be the 45-foot depth contour or at 6,000 feet offshore, whichever is first reached when proceeding offshore).

The San Clemente Shoreline Monitoring Program is intended to document coastal changes (i.e., shoreline morphology) in the broader region on longer time scales including seasonal, annual, and long-term. The San Clemente Shoreline Monitoring Program is funded through the end of 2025 in part by a grant from the California Coastal Commission (CCC).

The Shoreline Monitoring Program includes beach profile data collection each spring (May) and fall (October) along 12 shore-perpendicular beach profile transects located between Doheny State Beach to the north and Cotton's Point near the City of San Clemente's southern terminus. Six of these locations are historical transects utilized in the Coast of California Storm and Tidal Waves Study for the San Diego Region. Five of the locations were established in October 2001 specifically for the City of San Clemente's Shoreline Monitoring Program. The twelfth transect was established at North Beach to monitor the movement of opportunistic beach sand material placed in May 2005 and November 2017.

More recent shoreline monitoring efforts have used aerial imagery to measure shoreline changes. Additional information on shoreline changes from CoastSat indicate an average shoreline change of -1.8 feet per year between Doheny State Beach and San Clemente Municipal Pier, with the greatest shoreline changes from the east end of Doheny State Beach to Capistrano Bay District. CoastSat is tool that uses satellite imagery (from 1984 to the present) to determine shoreline positions over time (Vos et al. 2019).

In addition, aerial imagery from unmanned aerial vehicles has been used by the University of California, Irvine to monitor beaches in South Orange County. The University of California, Irvine, in partnership with State Parks, involves monthly monitoring using drones with the work aimed at improving the understanding of erosion trends to support coastal resilience measures.

The County of Orange (County) has installed CoastalCOMS monitoring stations at Capistrano Beach and Poche Beach to collect data for analysis of shoreline change. CoastalCOMS analytics products collect and analyze coastal surveillance video from cameras for automated tracking of beach width, usable beach area, and public usage. Shoreline position and wave activity are tracked over time and provided as both raw and processed/reported data that can be correlated back to storm impacts, tidal events, human use/influence, long-term weather patterns, and specific engineering or operational activity in support of resource management and allocation. Quarterly reports summarize the beach behavior information.

Coastal Processes Overview

The physical processes of sediment transport along the coastline can be characterized using a sediment budget approach of a littoral cell:

- **Bathymetric or topographic barrier:** A physical shoreline feature such as a shoreline headland or submarine canyon
- **Littoral cell:** A coastal compartment or segment of shoreline between two topographic or bathymetric barriers that minimizes sediment transport between the adjacent upcoast or downcoast shoreline
- **Sediment budget:** Accounts for sources, sinks, and storage of sediment within a littoral cell over a defined period
  - **Balanced sediment budget:** A shoreline with stable beaches
  - **Accreting beaches:** A sediment budget with a greater number of sources indicates a surplus of sediment and a shoreline with accreting beaches
  - **Eroding beaches:** A greater number of sinks indicates a deficit of sediment and a shoreline with eroding beaches

Sediment sources include watersheds (i.e., fluvial sources), bluffs, dunes, and beach nourishment. Historically, most sediment on beaches originated from the upland watershed (Griggs and Savoy 1985; Richmond et al. 2007). Natural hydrologic processes erode sediment from upland areas that is transported to the coastline via rivers, streams, and creeks (i.e., fluvial sources). Human development activities in watersheds have effectively reduced the natural sediment supply to the coastline as urban development hardens landscapes limiting erosion and sediment mining removes sediment, while dams, reservoirs, debris basins, other flood-control structures prevent sediment from being delivered to the coastline. Sediment sources from the coastline include the erosion of coastal bluffs and dunes. Beach nourishment activities have been conducted to artificially increase the sediment supply along the coastline. Sediment sinks include aeolian (i.e., wind) losses to coastal sand dunes, cross-shore transport to the offshore, or losses to deeper waters via submarine canyons.

Understanding Coastal Processes

Once sediment enters the littoral transport system and exposed to tidal and wave actions, it can be moved either on or offshore (cross-shore transport) or through the littoral cell along the beach (longshore transport). The shape and width of beaches are influenced by ocean water levels that are driven by astronomical tides, sea level rise, storms, and global climatic oscillations.

Ocean water levels offshore of Orange County are mixed, semidiurnal tides with two unequal highs and two unequal lows occurring each day. NOAA monitors ocean water levels and establishes tidal datums. The closest tidal datum location is at Newport Bay (Station 9410580), while the closest monitoring location is at La Jolla (Station 9410230). Tidal datums based on the 19-year tidal epoch from 1983 to 2001 at Newport Bay and La Jolla are shown in Table 1. The tidal datums include extreme recorded water levels and defined vertical means representing the average daily peak highs and lows (i.e., mean higher high water [MHHW], mean high water [MHW], mean low water [MLW], and mean lower low water [MLLW]). Ocean water levels are also affected by long-term increases in mean sea levels.

Table 1
NOAA Tidal Datums

Datum	Water Level (feet NAVD88)	
	Newport Bay (9410580)	La Jolla (9410230)
Highest Observed Water Level	+7.49 (January 28, 1983)	+7.62 (November 25, 2015)
MHHW	+5.23	+5.14
MHW	+4.50	+4.41
Mean Sea Level	+2.59	+2.54
MLW	+0.74	+0.72
MLLW	-0.18	-0.19
Lowest Observed Water Level	-2.53 (January 20, 1988)	-3.06 (December 17, 1933)

Notes:
Tidal datums based on 1983 to 2001 tidal epoch.
NAVD88: North American Vertical Datum of 1988
Sources: NOAA 2003, 2017

Water levels in the nearshore are affected from storms and fluvial flows. Storms can increase water levels above tide water levels from storm surges depending on barometric pressure, wind shear, and wave setup. Fluvial flows from rainfall in the watershed or dam releases can also result in localized increases in ocean water levels, particularly for enclosed waterbodies.

Global climatic oscillations such as the El Niño Southern Oscillation (ENSO) and Pacific Decadal Oscillation (PDO) can impact ocean water levels along the West Coast on a longer time scale compared to astronomical tides. The ENSO occurs every 4 to 7 years and results in temporary increases in ocean water levels for 1 to 2 years. In addition, strong ENSO events generally correspond to fluvial flooding events. The PDO occurs on a longer time scale and decreases ocean water levels.

Littoral sediment transport is driven by waves that generate cross-shore and longshore currents. The Channel Islands partially protect the Southern California coastline, limiting the wave exposure from deepwater wave sources. Waves impacting the Orange County coastline are produced by the following four sources (USACE 2013):

- Northern hemisphere swell is derived from extratropical cyclones that occur in the northern Pacific Ocean. This comprises the most severe waves reaching the Orange County coast, and these waves usually have the greatest impact of all the wave sources. These swells generally approach from a swell window of from 275 degrees to 285 degrees.
- Southern hemisphere swell is derived from extratropical cyclones from the South Pacific Ocean with the majority occurring from spring through early fall. These swells approach from approximately 170 degrees to 215 degrees.
- Tropical storm swell is derived from hurricanes off the west coast of Mexico during the summer and early fall. Most of these hurricanes take a westerly track sending swell out to the Pacific Ocean. On occasion, a northwest track sends swell up to Southern California, with the swell window ranging from 155 degrees to 200 degrees.
- Local sea is the term applied to steep, short period waves, which are generated by local winds and northwest winds in the outer coastal waters. The local winds can be further separated into pre-frontal winds from the southeast, gradient winds during the passage of a winter low pressure system from the west, and westerly sea breezes.

Beach Morphology and Cross-Shore Transport

The beach morphology is impacted by the wave climate causing sediment movement via cross-shore and longshore transport processes. Seasonal changes to the beach width occur in response to the ocean water levels and wave climate. In general, smaller longer period waves during the summer result in relatively wider beaches, while larger, shorter period waves during the winter erode and narrow the beach, as illustrated in Figure 2.

Cross-shore transport is the movement of sediment from wave and tidal action in the surf zone near the shoreline. Sediment movement occurs perpendicularly to the shoreline, either on or offshore. Offshore transport occurs from larger winter waves move sediment offshore, narrowing beaches and forming an offshore sandbar. The winter beach profile illustrates the berm erosion from the beach to the offshore sandbar. The formation of the offshore sandbar causes waves to break farther offshore and dissipates wave energy. Conversely, summer beach profiles build back up from sediment transport in the onshore direction from the offshore sandbar to the beach. Onshore transport is also a source of sediment when beach nourishment is done by nearshore placement, which moves sediment onto the beach.

Longshore Transport

Longshore transport occurs when waves approach the shoreline at an oblique angle resulting in the movement of sediment in the downcoast direction (Figure 3). Over time, this results in the net movement of sediment along the shoreline, commonly referred to as longshore drift. The longshore drift continually moves sediment downcoast until sediment is lost by a topographic barrier (e.g., submarine canyon) or intercepted by a human-made barrier such as a harbor entrance that stops longshore transport. The predominance of wave energy reaching the Orange County coast from the northern hemisphere results in wave driven currents from northwest to southeast throughout the winter and spring and cause most of the longshore sediment transport. Typically, in the summer, there is a seasonal reversal in longshore sediment transport from southern swells. Variable climatic cycles result in a range of conditions from dominant southeastward sediment transport over certain periods, followed by periods of more balanced sediment transport directions. The shoreline morphology has equilibrated over time to follow predominant conditions and over the long-term is oriented to southeastward sediment transport, with sediment inputs to the littoral cells typically from the northwest and outputs from the littoral cells typically in the southeast.

Oceanside Littoral Cell

The Oceanside Littoral Cell, as shown in Figure 4, extends from Dana Point to Point La Jolla in San Diego County. It is bounded by the shoreline headlands at Dana Point Harbor and the La Jolla/Scripps Canyon at the south end. The Laguna Sub-Cells extending from Corona Del Mar to Dana Point is the adjacent littoral cell to the north of the Oceanside Littoral Cell. The adjacent littoral cell to the south is the Mission Bay Littoral Cell, which is from La Jolla to Point Loma. The Oceanside Littoral Cell shoreline consists of relatively narrow, semicontinuous sand or cobble beaches backed by wave-cut coastal bluffs. The natural sediment supply is from rivers and bluff erosion. Major fluvial sources are the San Juan Creek, Santa Margarita River, San Luis Rey River, and San Dieguito River with minor fluvial sources from the San Mateo and San Onofre Creeks. Additional sediment sources include coastal bluff and terrace erosion. The damming of rivers and use of shoreline protection measures along coastal bluffs has resulted in an overall 47% reduction in the Oceanside littoral sediment supply (Patsch and Griggs 2006). Barriers to littoral transport include Dana Point Harbor, Oceanside Harbor and coastal lagoons (Agua Hedionda, Batiquitos, San Elijo, and Los Penasquitos Lagoons). Sand bypassing to artificially pass sand across the barrier is conducted at Oceanside

Harbor and Agua Hedionda Lagoon. Beach nourishment is also conducted periodically within the Oceanside Littoral Cell including the large-scale San Diego Association of Governments (SANDAG) beach nourishment project conducted south of Oceanside. Sediment sinks include offshore losses in the vicinity of Oceanside Harbor and submarine canyons, such as the Carlsbad, Scripps, and La Jolla Submarine Canyons.

Vulnerabilities and Coastal Conditions

The South Orange County coastline is vulnerable to coastal storm wave damage to public facilities and private homes along the coastline. Beaches naturally protect the coastal bluffs and structures from storm wave damage, but the loss of beaches has reduced this protection and limited recreational space. It is expected that the continual loss of beaches will allow waves to directly impact and threaten coastal structures.

For this study, the South Orange County coastline has been delineated into the segments listed in Table 2. The segments and beaches can be seen in in Figure 5. The South Orange County coastline contains beaches backed by coastal bluffs. Beaches contain adjacent parking lots, public facilities, or private homes that are bordered by the Los Angeles to San Diego (LOSSAN) railroad corridor and Pacific Coast Highway. The LOSSAN railroad corridor, operated by the Southern California Regional Railroad Authority, runs parallel to the coastline and fronts the coastal bluffs. The U.S. Department of Defense has designated the LOSSAN railroad corridor as a Strategic Rail Corridor, a vital link for passenger and freight services that includes rail access through Marine Corps Base Camp Pendleton. The railroad is constructed on a conventional elevated rock ballast. Portions of the railroad are protected by rock riprap located seaward of the railroad. Landward of the railroad, the Pacific Coast Highway/El Camino Real also runs parallel to the railroad and shoreline. Specific features and previous storm wave damage along the South Orange County coastline are described in the following sections.

Table 2
South Orange County Coastline Segments

Segment	Beaches	Jurisdiction
Dana Point Harbor	Dana Point Harbor	County
Doheny State Beach	Doheny State Beach	State
City of Dana Point	Capistrano Beach Park	County
	Capistrano Bay District	Private
	Poche Beach	County
City of San Clemente	Shorecliffs	Private
	Capistrano Shores	Private

Segment	Beaches	Jurisdiction
	North Beach	City of San Clemente
	Linda Lane Park	
	San Clemente Municipal Pier	
	T-Street Beach	
	Calafia Beach Park	State
	San Clemente State Beach	State
	3800 Block of Vista Blanca to Cotton's Point	Private

The South Orange County project study area is within the northern portion of the Oceanside Littoral Cell (i.e., Dana Point Harbor to San Mateo Point) that can be referred to as the Dana Point Sub-Cell. This section of shoreline is characterized by varying low and high-relief coastal sections consisting of long, smoothly curving sandy beaches backed by the LOSSAN railroad corridor/right of way, Pacific Coast Highway, and coastal bluffs. The beach profile consists of a relatively thin layer of sand overlying hard bedrock substrate. In general, the sandy beach has a beach berm, relatively steep beach face (i.e., foreshore), and more gently sloped in the nearshore.

The dominant sediment source in the Dana Point Sub-Cell is from fluvial sources, which are primarily from San Juan Creek. San Mateo Creek supplies sediment to the coastline south of the Cyprus Shore segment, though this sediment can move northward in a southern swell condition.

Because the dominant longshore transport is to the south/southeast, sediment from San Mateo Creek, which is only a minor source to the Oceanside Littoral Cell, would mainly contribute to beaches south of Cyprus Shore and the shoreline along Camp Pendleton in San Diego County south of the project study area.

Natural fluvial sediment sources from the San Juan, San Clemente, and San Mateo Creeks have been significantly reduced due to dams and other structures that prevent historically significant volumes of sediment from being delivered to the coastline. Currently, fluvial sediment delivery to the coastline occurs mainly during flood events. The only sediment sink in the Dana Point Sub-Cell is littoral transport to the south to the southern portion of the Oceanside Littoral Cell, which means San Mateo Creek is not a major source of sediment for the Dana Point Sub-Cell. Sediment losses to offshore transport beyond the depth of closure, submarine canyons, or aeolian transport are estimated to be negligible in the project study area.

Historical sediment budgets for the Dana Point Sub-Cell have varied based on wave climate (USACE 1991). Under natural conditions (1900 to 1938), prior to construction of dams and harbors, the Dana Point Sub-Cell was relatively balanced. During a mild, uniform wave climate (1960 to 1978), the littoral cell was slightly accreting with strong littoral transport to the south. A more variable wave climate (1983 to 1990) resulted in a relatively balanced sediment budget due to periodic net littoral transport to the north. While the long-term sediment budget indicates a relatively balanced littoral system, the Dana Point Sub-Cell is more dynamic on a year-to-year basis oscillating between erosion and accretional conditions. Another assessment of the littoral sediment budget for the Dana Point Sub-Cell indicated variations in the net sediment transport during dry and wet years (Coastal Environments 2014). It was estimated that there is 56,000 cy per year deficit in sand supply during dry years and a 3,000 cy per year surplus during wet years. Thus, prolonged dry years would result in more shoreline erosion.

In summary, littoral transport conditions between the 1960s and 1980s in the Dana Point Sub-Cell was primarily affected by the construction of Dana Point Harbor, a large-scale beach nourishment, and larger storms in the early 1980s. Since the 1990s, the shoreline along the Dana Point Sub-Cell has a lack of sediment supply that has resulted in a chronic, long-term erosional condition (USACE 1991, 2012; Coastal Environments 2014). Additional details of the historical beach erosion issues and existing vulnerabilities and coastal conditions are provided in the following sections.

Dana Point Harbor

Dana Point Harbor is a recreational and commercial marina managed by Orange County Parks and through a public-private-partnership under a long-term lease with the Dana Point Harbor Partners. Harbor facilities include 2,400 boat slips, boat launch ramps, commercial fishing and whale watching docks, yacht clubs, a protected beach area called Baby Beach, and a fishing pier. The harbor is protected by two breakwaters constructed and maintained by the USACE; the West Breakwater runs parallel to the shoreline and the East Breakwater extends perpendicular to the shoreline forming the entrance channel. The rubble mound breakwaters are semipermeable with multiple layers of varying-sized riprap and impermeable core that allow some flow through the breakwaters. The USACE is responsible for maintaining the navigation channels and the County maintains the berthing basins. Since the 1990s, the County has funded multiple maintenance dredging events to remove sand accumulation from inside the harbor along the West Breakwater. A federal funding allocation for harbor maintenance has been difficult to secure given the harbor’s status as a recreational harbor, and relatively small dredge volumes cause it to be a low priority. Large storms have dislodged stones along the seaward side of the West Breakwater, which required repair to the breakwater following 1982–1983 storms. Access dredging is required to conduct repairs to the West Breakwater, which is planned for 2024.

There is minor contribution of sediment to the Dana Point Sub-Cell from littoral transport from the Laguna Sub-Cells (USACE 1991). However, littoral transport from the north would be intercepted by the Dana Point Harbor. Sediment accumulation in Dana Point Harbor occurs from littoral sediment transport through the breakwater, forming a shoal along the harbor side of the West Breakwater.

Maintenance dredging has been conducted by the County in 1990, 2000, 2009, and 2016. For the dredging episode in 1990, the County was not able to obtain permission from the California Regional Water Quality Control Board to place sand offshore Capistrano Beach Park, and sediment was transported by barge to U.S. Environmental Protection Agency Ocean Dump Site LA-3, located approximately 12 miles northwest of the harbor. Since then, sediment has been placed at Baby Beach within Dana Point Harbor and placed downcoast on Capistrano Beach Park.

Doheny State Beach

Doheny State Beach extends approximately 1.2 miles south from Dana Point Harbor to Capistrano Beach and is bisected by San Juan Creek, as shown in Figure 6. The lower portion of the creek was channelized into a concrete-lined trapezoidal channel between Camino Capistrano Road to Pacific Coast Highway in the 1960s. Downstream from the Pacific Coast Highway, the creek has concrete banks and earthen bottom with sand, gravel, and cobbles (Coastal Environments 2014). At the northern end between Dana Point Harbor and San Juan Creek, the west area includes a relatively wide beach area, park area, campsite, and other recreational facilities. The Doheny State Beach Campground is located on the east area, south of San Juan Creek. The Doheny State Beach Foundation, in cooperation with California State Parks, manages the park facilities including visitor center, aquarium, interpretive, and conservation programs.

The west area of Doheny State Beach has an approximately 1,400-foot-long, relatively wide, stable beach and is fixed by the Dana Point Harbor East Breakwater on the west side, Thor's Hammer rock groin on the east side, and 2-foot retaining wall on the north side. The Thor's Hammer rock groin was constructed along the west side of San Juan Creek to compartmentalize the beach between San Juan Creek and Dana Point Harbor to prevent erosion of the adjacent beach (Figure 6). Typically, from late spring to late fall, a natural beach berm forms across the creek mouth separating the creek and ocean. Large flows from San Juan Creek can and do breach the berm.

The relatively wide beach extends into the east area along the Doheny State Beach Campground. Flooding of the campground area from high tides previously occurred in June 2004; subsequently a beach berm was constructed in front of the campground to protect it from high tides in July (Coastal Environments 2014). Downcoast, the beach visibly narrows where the Pacific Coast Highway parking lot, LOSSAN railroad corridor, and Pacific Coast Highway become parallel to the coastline. The beach fronting the parking lot has experienced a loss of sand and an increase in exposed cobble. Damages have been observed along the parking lots and bike path including undermining of concrete slabs (Figure 6) and uprooting of palm trees. Rock has been placed along portions of the parking lot in response to the eroding beach. Littoral sediment transport conditions at Doheny State Beach differs from other areas in the Dana Point Sub-Cell because it has the following: 1) a more sheltered wave exposure; 2) a south-facing shoreline orientation; and 3) the only direct fluvial sediment supply, Dana Point Harbor, shelters Doheny State Beach from the northern hemisphere swells, particularly for the west area. Fluctuations in the shoreline are expected to be relatively small during dry years without a fluvial sand supply, while being relatively stable during wet years because the fluvial sand supply effectively offsets erosion during large winter storms.

Historically from the 1960s to 1980s, the sediment supply was significantly increased by beach nourishment at Doheny State Beach, particularly during the time of construction of Dana Point Harbor. A summary of climatic and coastal extreme events and beach nourishments is provided in Table 3. Large flood events from San Juan Creek would provide an increase in the sediment supply, while extreme coastal events (e.g., ESNO) would result in erosion of the sediment.

Table 3
Historical Climatic and Coastal Extreme Events and Beach Nourishments at Doheny State Beach

Year	Climatic and Coastal Extreme Events	Beach Nourishment
1916	San Juan Creek flood (55,000 cfs)	--
1938	San Juan Creek flood (13,000 cfs)	--
1943	San Juan Creek flood (5,800 cfs)	--
1964	San Juan Creek flood	94,000 cy from San Juan Creek placed at west area
1966	ENSO and San Juan Creek flood (9,000 cfs)	690,000 to 840,000 cy from Camp Pendleton placed at east area
1969	San Juan Creek flood (22,400 cfs)	212,000 cy from San Juan Creek placed at beach 365,000 cy from San Juan Creek placed at west area
1970	NA	125,000 cy of dredged material from Dana Point Harbor placed offshore to enhance surfing
1978	San Juan Creek flood (14,700 cfs)	50,000 cy from San Juan Creek placed at beach
1980	Strong ENSO and San Juan Creek flood (11,400 cfs)	80,000 cy from San Juan Creek placed at beach
1983	January to March ENSO storms and San Juan Creek flood (5,770 cfs)	--
1993	San Juan Creek flood (8,320 cfs)	--
1995	San Juan Creek flood (25,600 cfs)	--
1998	January ENSO storm and San Juan Creek flood (18,300 cfs)	--

Sources: CCSMW 2005; Coastal Environments 2014
Note:
cfs: cubic foot per second

Sediment at Doheny State Beach is generally composed of sands with varying amounts of gravel and cobbles from alluvial sediments from San Juan Creek; intermittent deposits of gravel and cobbles have been reported for the East Beach area (Ninyo and Moore 2015). The beach profile at Doheny State Beach in the vicinity of San Juan Creek reflects a typical sandy beach with a beach berm, relatively steep beach face, and more gently sloped in the nearshore. Since 1980, the west area beach width has generally ranged from approximately 320 to 500 feet, while the east area beach width has ranged from approximately 140 to 500 feet. Downcoast of the Doheny State Beach Campground parking lot, the beach berm has eroded back to the Pacific Coast Highway parking lot and the beach face visibly narrows. For the East Beach, the large beach widths occurred following large storms in the 1980s and has typically ranged from approximately 150 to 350 feet since 1990 (Coastal Environments 2014).

Dana Point Segment

The Dana Point segment extends from Palisades Drive (Beach Road) to Camino Capistrano and includes Capistrano Beach Park and Capistrano Bay District.

Capistrano Beach Park, which is owned and managed by County of Orange Parks Department (OC Parks), includes a parking lot and limited amenities that are located seaward of the LOSSAN railroad corridor and Pacific Coast Highway. At the north end of the beach, wave action has eroded the sandy beach, exposing a cobble foundation, and has also undermined the pavement of the bike path. 1-cy sand-filled geotextile units, or sand cubes, were placed at the south end of the park in 2016 on an emergency basis, and again in 2019 to protect the City of Dana Point stormwater infrastructure and bike trail because rock was not allowed by the CCC. Coastal storms have also damaged the 1,000-foot-long parking lot at the south end and eroded the sandy beach area. Riprap and sandcubes have been placed along portions of the parking lot edge in response to the beach erosion and portions of the parking lot were removed due to undermining and collapse (OC Parks 2021a). Figure 7 shows storm damage at Capistrano Beach Park. Storms in winter 2018 damaged portions of a basketball court, caused the boardwalk to collapse, destroyed firepits, and threatened a restroom building, all of which have been removed. In 2021, approximately 150 feet of geotextile bags filled with 4 cy of sand were placed to protect the parking lot. Approximately 220 linear feet of sandcubes at the southernmost end of the Park are currently being replaced with riprap. To address the ongoing beach erosion at Capistrano Beach Park, OC Parks has completed a feasibility study for a Nature-Based Coastal Resilience Pilot Project.

Along Capistrano Beach Park, the beach profile has eroded back towards the parking lot. The riprap and sandbags help to mitigate the beach erosion, as shown in Figure 7. Since 1985, a landward retreat of the shoreline has been observed; by 2019 the shoreline reached the rock revetment fronting the parking lot (OC Parks 2021b). Significant beach nourishment occurred in the 1960s and 1970s (Table3). Sand has been placed as a byproduct of harbor maintenance dredging conducted sporadically by the County (OC Parks 2021b). Nearshore placement at Capistrano Beach Park occurred in 2000, 2009, and 2016.

The next 1.5-mile segment of the coastline is the Capistrano Bay District, which is fronted by 205 residential homes along Beach Road. Site observations indicate oceanfront homes that are protected by seawalls or rock revetments (Figure 7). The beach profile along the Capistrano Bay

District and Capistrano Shores has also eroded back to the oceanfront homes requiring seawalls or rock revetments to protect homes from waves. The homes are situated atop the beach berm and exposed to normal tide and wave conditions. It should be noted that access to Beach Road, which is the only access to the residential homes, could be threatened by severe erosion at the south end of Capistrano Beach Park (OC Parks 2021a).

Poche Beach is a 1,500-foot-long beach that crosses the boundary of Dana Point and San Clemente extending from the relic San Clemente Creek mouth to Capistrano Shores. A 230-foot segment of the beach is owned by the County in the City of Dana Point. The remaining 1,270-foot segment adjacent to Shorecliffs Beach Club is within the jurisdiction of the City of San Clemente. Beach access across the railroad is via a pedestrian catwalk within the channel underneath the railroad and adjacent to stormwater infrastructure (Figure 7). At Poche Beach, natural sediment from San Clemente Creek (Prima Deshecha Canada flood control channel) has been eliminated (USACE 1991). Except for the Shorecliffs Beach Club, a sandy beach berm is visible to the railroad. Beach width monitoring has indicated the shoreline is accreting at this location; however, this is not consistent with shoreline trends along the San Clemente City Beaches (USACE 2012).

The Capistrano Shores 0.7-mile segment is lined with oceanfront homes. These homes face the same beach erosion issues as Capistrano Bay District and some homes are protected by seawalls or rock revetments and are exposed to tide and wave action, which can be large during extreme conditions (Figure 7).

San Clemente Segment

The San Clemente City Beaches segment extends approximately 2.3 miles from Poche (in Dana Point) and Shorecliffs Beach Club (in the City), North Beach to Calafia Beach Park including Linda Lane Park, San Clemente Municipal Pier, and T-Street Beach south all the way to the Orange County/San Diego County line near San Mateo Point. The existing conditions of the San Clemente City Beaches are shown in Figure 8. The San Clemente Beach Coastal Trail, also known as the California Coastal Trail, is a sandy dirt (decomposed granite) and gravel path that runs along the back beach of this entire shoreline segment from Avenida Estacion at North Beach to at Calafia Beach Park.

The LOSSAN railroad corridor within this segment is at a relatively lower elevation than other portions of the railroad with the lowest portions of the railroad are located at the Metrolink stations at San Clemente Station and the San Clemente Municipal Pier. Orange County Transportation Agency (OCTA) maintains a 75-foot-wide right of way along the beach in the City of San Clemente. Rail service shutdowns occurred in the 1960s and 1970s when waves overtopped the railroad ballast and eroded the embankment in the vicinity of San Clemente Municipal Pier. Beach erosion and storm damage to the railroad led to the installation of rock riprap along portions of the railroad line on the seaward slope of the railroad. In 1993, service was shut down for 5 days following a mudslide in San

Clemente. Severe storm wave damage to the riprap protection and service interruptions have occurred following storms in 1998, 2016, and 2021 through 2023.

North Beach is backed by the LOSSAN railroad corridor and the California Coastal Trail on the landward side of the railroad. Residential homes atop the coastal bluffs landward of the California Coastal Trail. There is pedestrian at-grade crossing with safety controls across the railroad at the south end of the Avendia Estacion parking area. On the beach, there is a concession and restroom facility. The northern 1,100-foot portion of the railroad is intermittently protected by riprap or vegetation.

The seaward side of the railroad along 204 Beach is continuously protected by riprap starting approximately 550 feet upcoast of the Dije Court beach access down to Linda Lane Park. For beach access, there are three pedestrian at-grade crossings with safety controls across the railroad (Dije Court, El Portal, and Mariposa) and one below-grade stormwater tunnel at Linda Lane Park. Erosion has occurred at the access tunnels at Dije Court and Linda Lane Park during high tides.

San Clemente Marine Safety Headquarters and parking lot are located seaward of the railroad near the San Clemente Municipal Pier. Beach access across the railroad is available at Corto Lane, Municipal Pier, and Trafalgar Canyon. The pier was damaged during ENSO storms in March 1983, which was estimated to have had 20 to 25-foot waves, and in 1988. Repair costs for the pier were approximately $2.1 million for the 1983 storm damage and approximately $2.3 million for the 1988 storm damage (USACE 2012). Similarly, the Marine Safety Building located on the beach, has experienced damage from large storms resulting in wave overtopping and erosion beneath the building piles. Repairs to the City’s Marine Safety Headquarters Building were made in 1986, 2003, and 2020, and the City is currently evaluating options for facility upgrades in place as well as in a location landward of the railroad.

Intermittent riprap protection resumes south of T-Street Beach to Calafia Beach Park. Beach access via pedestrian at-grade crossings with safety controls are located at the end of West Paseo de Cristobal (T-Street) and Leslie Park (Lost Winds) and below-grade stormwater tunnels at Riviera and Montalvo. Calafia Beach Park is operated by the City of San Clemente on State Park property and there is a pedestrian at-grade crossing with safety controls across the railroad. Beach erosion has resulted in a steeper beach profile, as shown in Figure 8. In addition, stormwater infrastructure has been subjected to blockage from sand accumulation and riprap has been installed for storm damage protection.

San Clemente City Beaches have varying beach widths. Beach width monitoring shows that the overall shoreline is marginally erosive with most of the damage to public facilities occurring from storm conditions (USACE 2012). Variations in the beach width are seen from aerial photographs, with relatively wider beach at inundations along the coastline. In general, relatively wider beaches occur at

North Beach, Linda Lane Park, San Clemente Municipal Pier, T-Street Beach, and Calafia Beach Park. The narrowing of the beach is seen in between North Beach and Linda Lane Park and corresponds to the length of shoreline with riprap protection along the railroad. Storm damage to the railroad riprap protection has typically occurred from ESNO storms in 1998 and 1993. Beach nourishment was conducted as part of the San Clemente Opportunistic Beach Sand Replacement Program, which placed 5,000 cy at North Beach in 2005 and 12,000 cy in 2016 with material trucked from a Santa Ana River sediment clearing operation.

San Clemente State Beach

The LOSSAN railroad corridor is relatively lower along San Clemente State Beach Park. Portions of the railroad, which runs along the base of the coastal bluffs, are protected by riprap. There is a below-grade stormwater tunnel connecting the park and beach.

Beach width monitoring shows that the shoreline at San Clemente State Beach is eroding (USACE 2012). Based on aerial photographs, the beach berm is covered with vegetation seaward of the railroad.

Cyprus Shores

The Cyprus Shores segment between San Clemente State Beach to Cotton Point has a narrow beach fronting the LOSSAN railroad corridor that continues parallel to the coastline and is backed by high coastal bluffs with residential homes in the Cyprus Shore community. There are two privately maintained beach accessways/tunnels (Avenida de Las Palmeras and Calle Ariana) beneath the railroad for the Cyprus Shores, Cotton's Point Estates, Breakers Homeowner's Association and Cyprus Cove communities. Along the 1,500-foot northern portion of the Cyprus Shores segment, the seaward slope of the railroad contains vegetation with some riprap at culverts. Then, a continuous riprap segment protects the seaward slope of the railroad until Trestles Beach; OCTA has historically used riprap to protect the railroad tracks. Along most of the coastline in the segment, the beach has eroded back to the riprap protected railroad. Without the sandy beaches, the railroad effectively becomes the beach profile directly exposed to tidal inundation and wave action. Currently, there is essentially no beach in front of the existing riprap, thus cutting off direct downcoast beach access to Trestles Beach. Moreover, because the riprap was simply placed and not part of an engineering revetment, continued beach erosion has resulted in scour of the sand under the rock and subsequent subsidence and rolling of the rock downslope towards the ocean to Trestles Beach.

The Cyprus Shores coastline experiences beach erosion and slope stability issues. In 2021, OCTA suspended railroad service between South Orange County (Laguna Niguel and Mission Viejo) and Oceanside because of detected movement of the railroad tracks along Cypress Shore and required emergency track repair, placing an additional 20,000 tons of riprap along the seaward slope of the railroad ballast. Also, foundation cracking to of a few homes atop the coastal bluffs and damage to the Cypress Shore community clubhouse parking lot worsened and was attributed to instability of the coastal bluffs. The slope instability is tied to an ancient landslide that has been reactivated (SC Times 2022). The railroad track movement in 2021 initiated the San Clemente Track Stabilization Project. In 2022, passenger train service between South Orange County and Oceanside was again suspended and freight train service reduced due to movement of the coastal bluffs. Construction of the San Clemente Track Stabilization Project started in November 2022 and was completed in March 2023. As of the time of writing of this Plan, railroad operations have resumed to normal service levels. However, an unrelated coastal bluff landslide near the central portion of the City of San Clemente, at the City-owned Casa Romantica historic building, has again interrupted rail service along this shoreline segment as of June 2023.

Regionwide Beach Erosion

The urbanization of watersheds, flood control infrastructure (e.g., dams, reservoirs, detention basin, and channelization and hardening of riverbanks) and sand mining has trapped a significant portion of the fluvial sediment in the upper watershed, resulting in an overall reduction in delivery of sand supply reaching the South Orange County coastline (USACE 1991, 2013). The available sediment is primarily delivered to the coastline during high rain events, hence the overall lack of sand in the littoral system is exacerbated during times of drought with no fluvial sand supply. Although the long-term net transport in South Orange County is to the south, shorter-term variations in the wave climate, particularly from storm events, will move sand upcoast and downcoast, as well as onshore and offshore from beaches. The culmination of these factors has resulted in background levels of mild, long-term beach erosion along the entire South Orange County coastline. This regionwide beach erosion is evidenced by fluctuations in the sandy beach area ranging from relatively narrow beaches during high wave energy and drought years, to relatively wider beach during low wave energy and wet years.

The review of existing vulnerabilities and coastal conditions verified that South Orange County is vulnerable to coastal storm wave damage to public facilities and private homes along the coastline. Most of the coastline is directly exposed to normal tidal and wave conditions including the coastline from the south end of Doheny State Beach to Linda Lane Park and from Cyprus Shores to Cottons Point including residential homes of Capistrano Bay District and Capistrano Shores and the railroad tracks along Buena Vista and Cyprus Shore. Homes in the Cyprus Shores community are also being threatened by instability of the coastal bluffs. Doheny State Beach and San Clemente City Beach still have some beach protection and are mainly threatened during extreme tide or storm conditions.

References

CCSMW (California Coastal Sediment Management Workgroup), 2005. *Assessment of Offshore Sand Resources for Potential Use in Restoration of Beaches in California*. Prepared by California Geological Survey.

Coastal Environments, 2014. *Updated Coastal Processes and Hydraulic/Hydrology Studies for Doheny State Beach Technical Report*. South Coast Water District. September 11, 2014.

Coastal Frontiers, 2023. *City of San Clemente Beach Monitoring Program Fall 2022 Beach Profile Survey Report*. March 2023.

Griggs, G. and L. Savoy, 1985. *Living with the California coast*. Sponsored by the National Audubon Society.

Ninyo and Moore, 2015. *Preliminary Geotechnical Study: Doheny Desalination Project Beach Facilities South Coast Water District Dana Point, California*. Prepared for Carollo Engineers. February 5, 2015.

NOAA (National Oceanic and Atmospheric Administration), 2003. "Published Bench Mark Sheet for 9410580, Newport Beach, Newport Bay Entrance, CA." *NOAA Tides and Currents*. April 21, 2003. Available at: https://tidesandcurrents.noaa.gov/benchmarks.html?id=9410580.

NOAA, 2017. "Published Bench Mark Sheet for 9410230, La Jolla, Pacific Ocean, CA." *NOAA Tides and Currents*. September 20, 2017. Accessed April 17, 2020. Available at: https://tidesandcurrents.noaa.gov/benchmarks.html?id=9410230.

OC Parks (Orange County Parks), 2021a. *Capistrano Beach County Park Nature-Based Pilot Project Feasibility Study Report*. Prepared by Moffatt and Nichol. June 2021.

OC Parks, 2021b. *Capistrano Beach County Park Beach Nourishment Study*. Prepared by Moffatt and Nichol. July 2021.

Patsch, K., and G. Griggs, 2006. *Littoral Cells, Sand Budgets, and Beaches: Understanding California's Shoreline*. Institute of Marine Sciences, University of California, Santa Cruz, California Department of Boating and Waterways, and California Coastal Sediment Management Workgroup. October 2006.

Richmond, J.A., O. Magoon, and B.L. Edge, 2007. *Where's the Sand? Reduction in the Delivery of Sediment to Coastlines*. Proceedings of Coastal Zone '07. July 2007.

SC Times (*San Clemente Times*), 2022. "Contending with Coastal Erosion – Cyprus Shore Residents Seek Permanent Protection." November 3, 2022.

USACE (U. S. Army Corps of Engineers), 1986. *Oral History of Coastal Engineering Activities in Southern California 1930-1981*. January 1986.

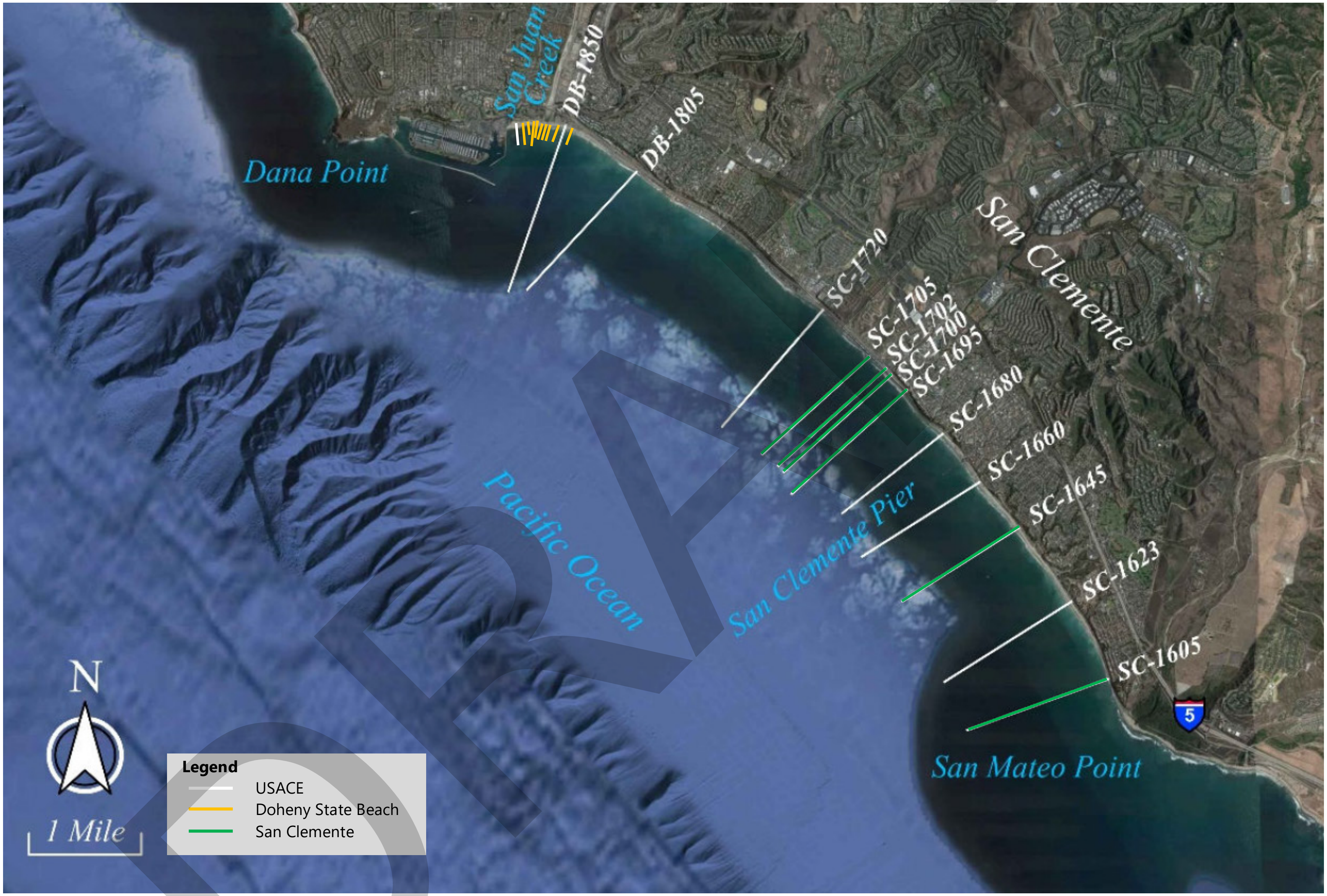
USACE, 1991. *Coast of California Storm and Tidal Waves Study, State of the Coast Report, San Diego Region*. USACE, Los Angeles District. September 1991.

USACE, 2012. S*an Clemente Shoreline Feasibility Study Orange County, California*. U.S. Army Corps of Engineers, San Clemente, California.

USACE, 2013. *Orange County Coastal Regional Sediment Management Plan*. Prepared for U.S. Army Corps of Engineers, County of Orange, and California Coastal Sediment Management Workgroup. Prepared by Everest International Consultants, Inc. in association with Science Applications International Corporation and Dr. Philip King. June 2013.

Vos, K., K.D. Splinter, M.D. Harley, J.A. Simmons, and I.L. Turner, 2019. *CoastSat: A Google Earth Engine-Enabled Python Toolkit to Extract Shorelines from Publicly Available Satellite Imagery*. Environmental Modelling & Software. Volume 122. December 2019.

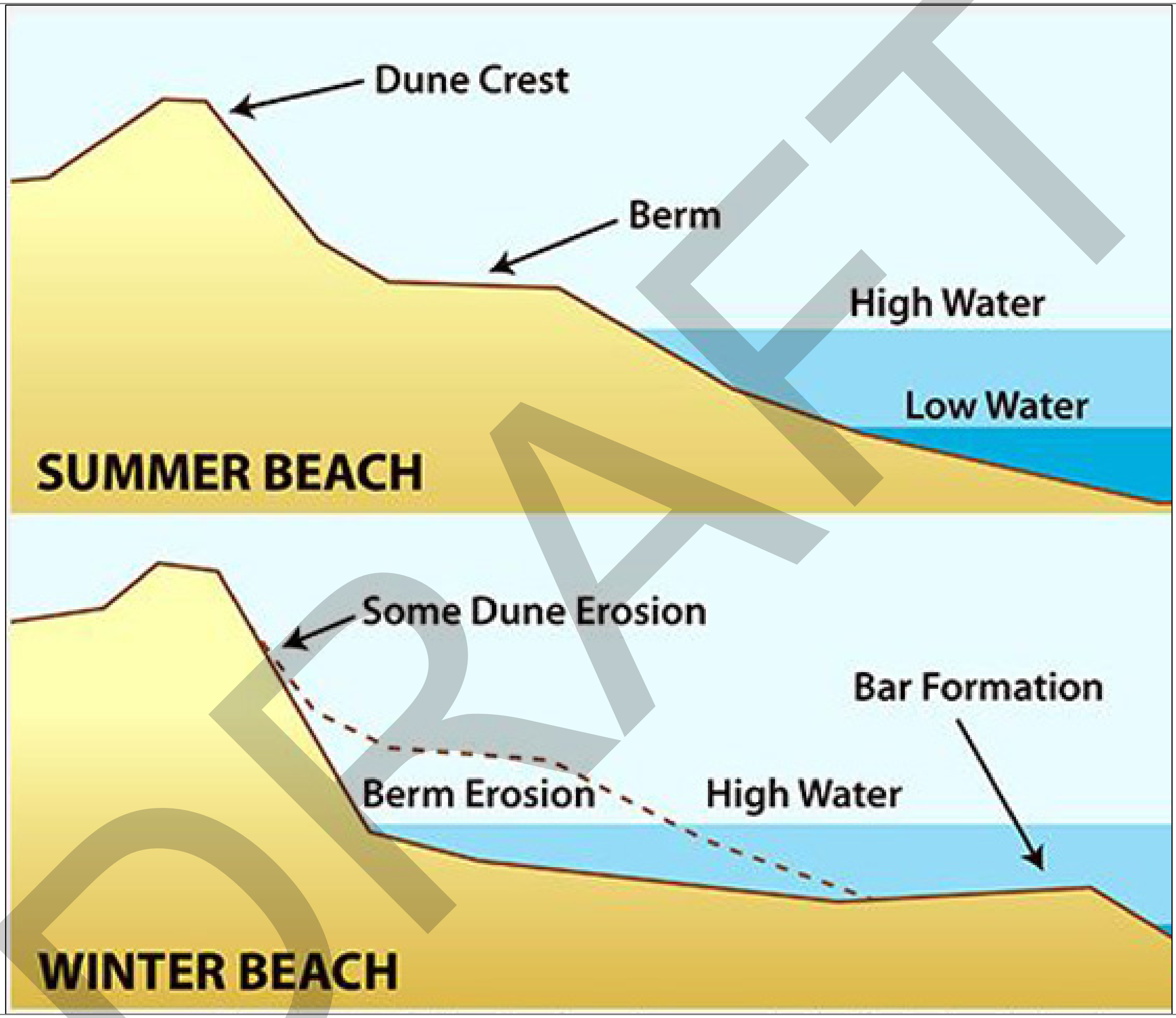
Figures



Notes: Background image from Coastal Frontiers 2023.

ANCHOR QEA

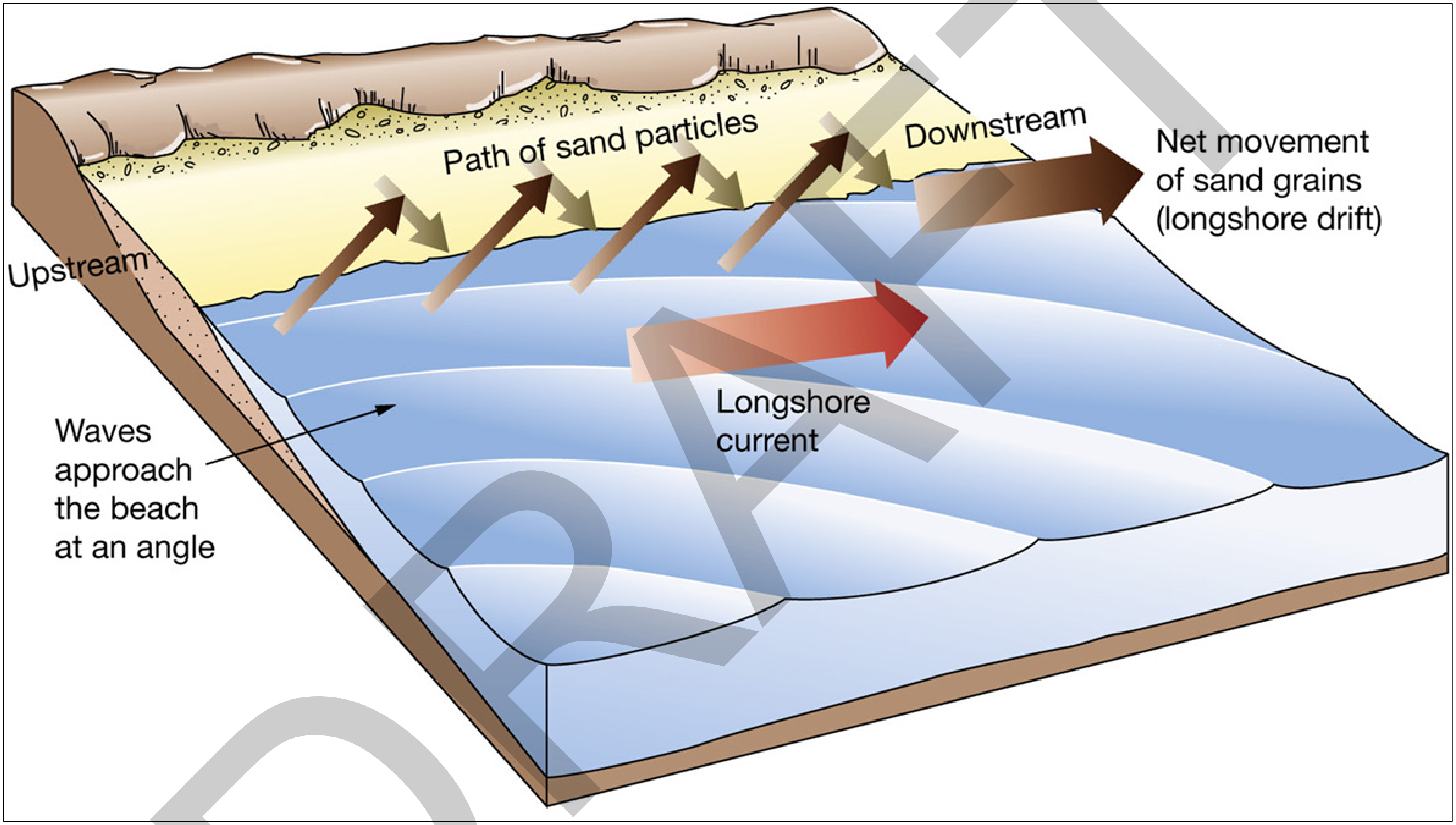
Figure 1
Shoreline Monitoring Locations
South Orange County Regional Coastal Resilience Strategic Plan
South Orange County Coastal Resiliency



Filepath: \\fuji\irvine\PROJECTS\OC Public Works\South OC Regional Coastal Resilience Strategic Plan\Draft Plan\Appendix F-Historical Shoreline Data and Trends\Figures\Figure 2-Cross-shore Transport.docx

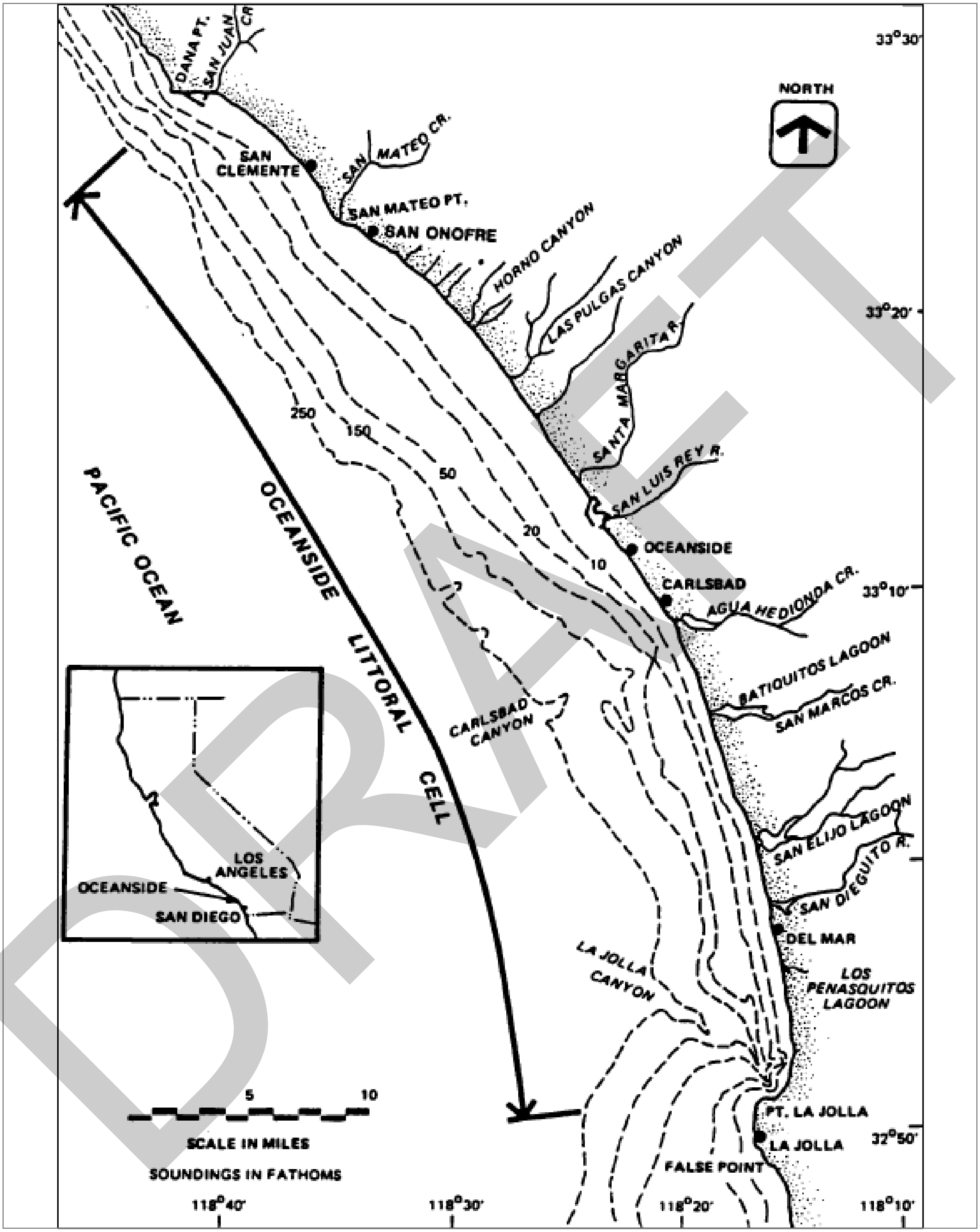
ANCHOR QEA

Figure 2
Schematic of Beach Morphology from Cross-Shore Transport
South Orange County Regional Coastal Resilience Strategic Plan
South Orange County Coastal Resiliency



ANCHOR QEA

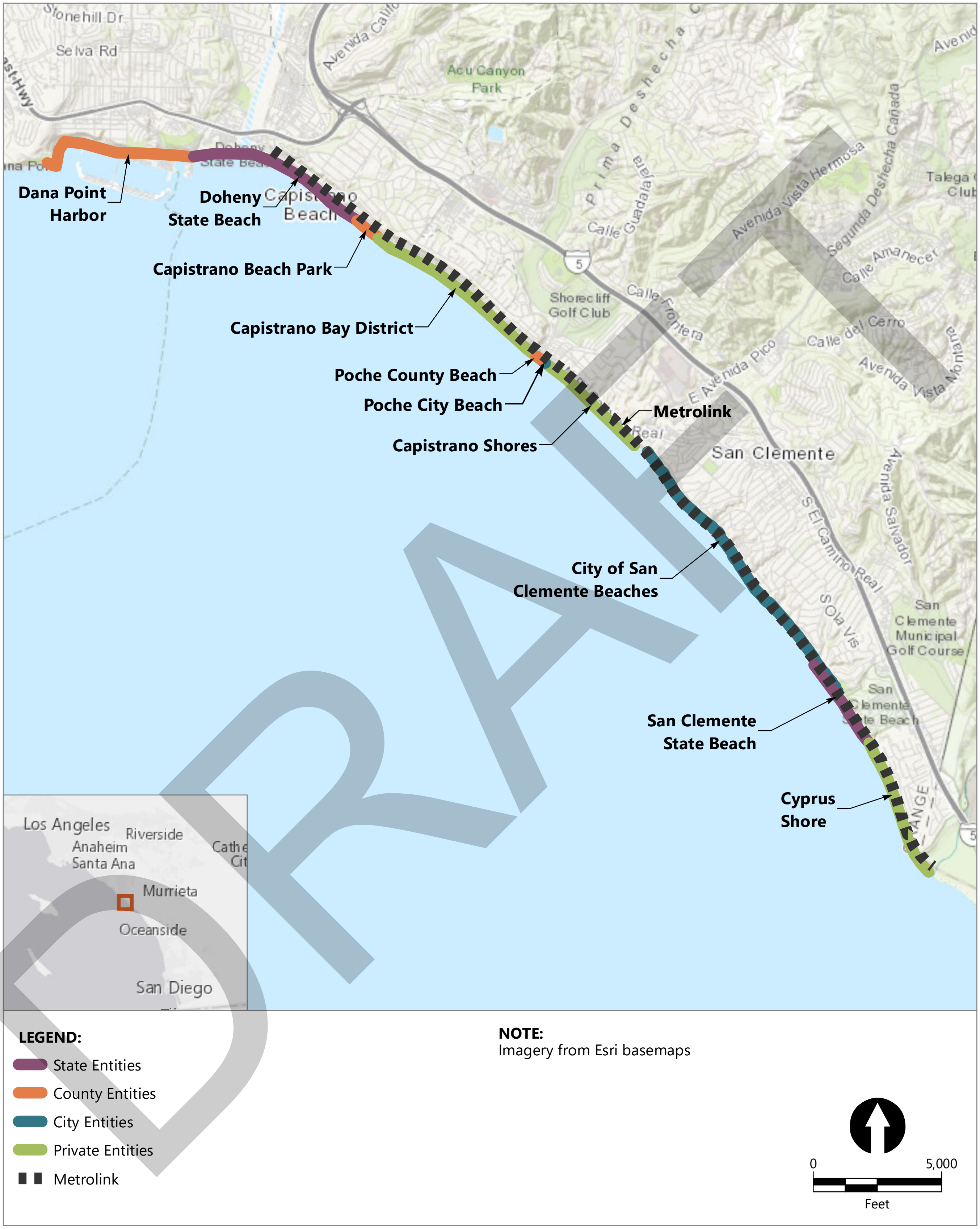
Figure 3
Schematic of Beach Morphology from Longshore Transport
South Orange County Regional Coastal Resilience Strategic Plan
South Orange County Coastal Resiliency



Source: USACE 1991

Figure 4
Oceanside Littoral Cell

DRAFT



Publish Date: 2023/05/04, 1:27 PM | User: bueoka
Filepath: Q:\Jobs\County_of_Orange_0939\Coastal_Resilience\Maps\AQ_CoastalResiliencyShorelines_rev1.mxd

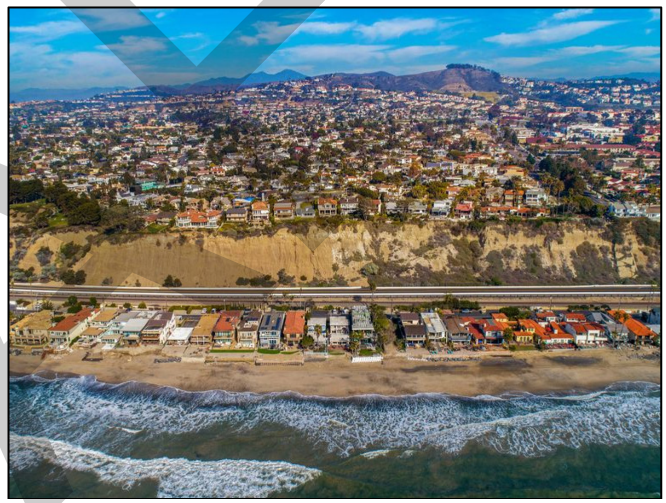
ANCHOR QEA

Figure 5
South Orange County Coastline
South Orange County Regional Coastal Resiliency Strategic Plan
South Orange County Coastal Resiliency

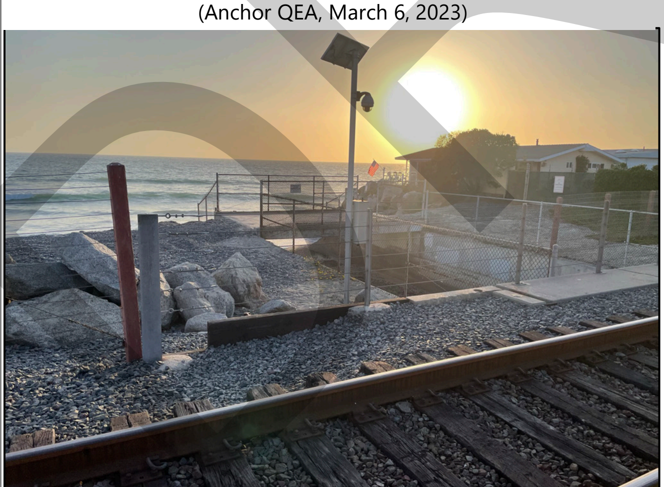
Capistrano Beach Park riprap and sandbags
(Anchor QEA, March 6, 2023)

Basketball court and boardwalk damaged in 2018 and removed
(Jeff Gritchen, Orange County Register/SCNG, December 4, 2018)

Capistrano Beach Park adjacent to Capistrano Bay District
(Anchor QEA, March 6, 2023)



Capistrano Bay District (Beach Road) oceanfront homes
(Beach Road Realty, 2019)



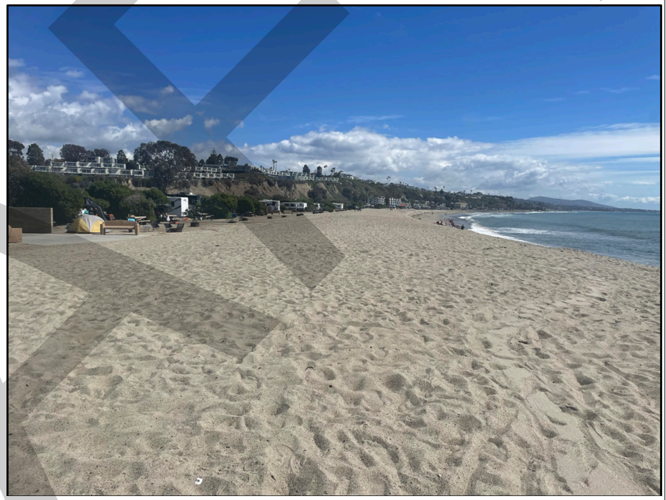
Stormwater infrastructure at Poche County Beach
(Anchor QEA, March 10, 2022)

Capistrano Shores from North Beach
(Anchor QEA, March 6, 2023)

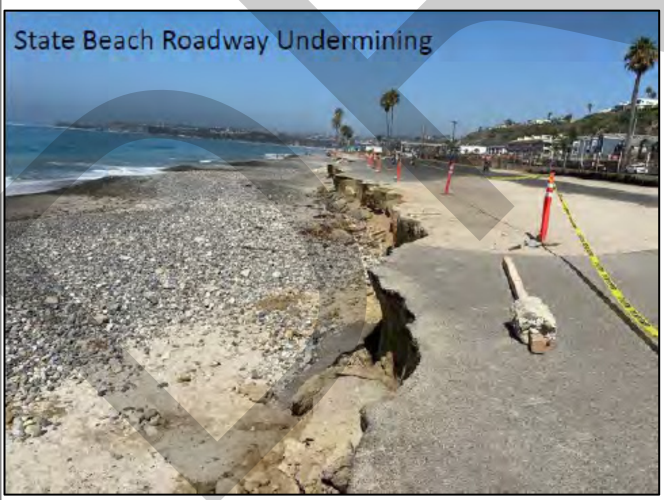
West area beach adjacent to Dana Point Harbor
(Anchor QEA, March 6, 2023)

West area beach with cobble in nearshore
(Anchor QEA, March 6, 2023)

San Juan Creek mouth and Thor's Hammer rock jetty
(Anchor QEA, March 6, 2023)



East area beach fronting campgrounds
(Anchor QEA, March 6, 2023)



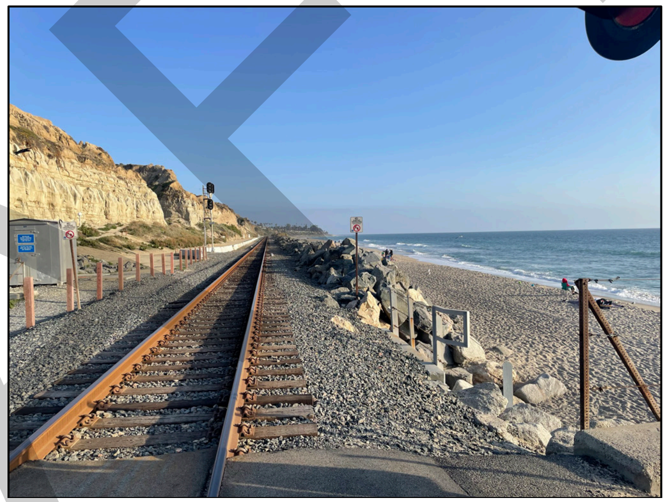
Undermining of parking lot (OC Parks 2021a)

Exposed cobbles June 2020 (OC Parks 2021a)

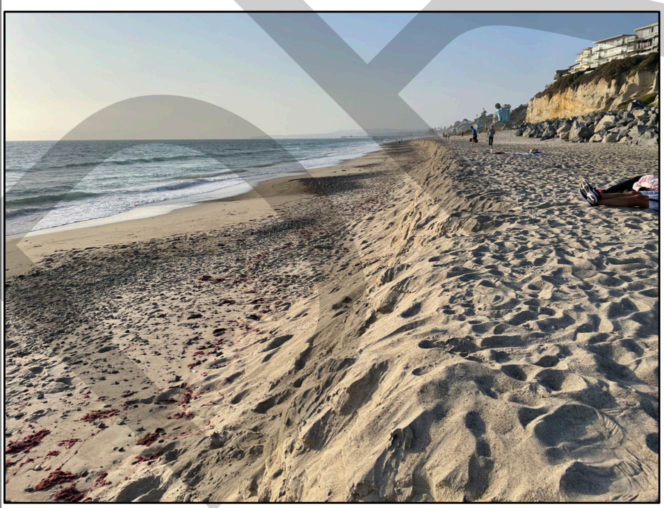
North Beach
(Anchor QEA, March 6, 2023)

San Clemente City Beach and Marine Safety Building
(Anchor QEA, March 6, 2023)

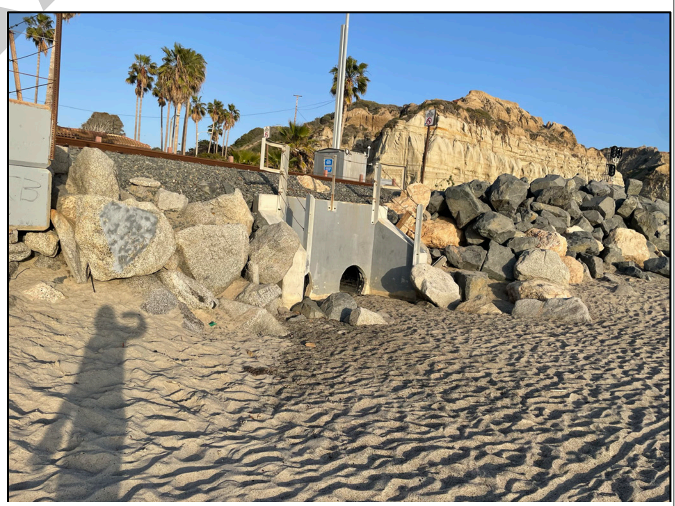
San Clemente Municipal Pier
(Anchor QEA, March 6, 2023)



LOSSAN Railroad with riprap
(Anchor QEA, March 6, 2023)



Califa Beach Park
(Anchor QEA, March 10, 2022)



Stormwater infrastructure at Califa Beach Park
(Anchor QEA, March 10, 2022)